

## New species of *Caloplaca* (lichenised Ascomycota: Teloschistaceae) from Kangaroo Island

G. Kantvilas<sup>a</sup> & S.Y. Kondratyuk<sup>b</sup>

<sup>a</sup> Tasmanian Herbarium, Private Bag 4, Hobart, Tasmania 7001, Australia.

E-mail: Gintaras.Kantvilas@tmag.tas.gov.au

<sup>b</sup> M.H. Kholodny Institute of Botany, Tereshchenkivska str. 2, 01601 Kiev-MSP-1, Ukraine.

E-mail: ksy\_a\_net@ukr.net

### Abstract

The new species, *Caloplaca gilfillaniorum* Kantvilas & S.Y.Kondr. and *C. piscatorica* Kantvilas & S.Y.Kondr., are described and illustrated, and their relationships with other species are discussed. The closest affinities of the former are with the Australian species, *C. kaernefeltii* S.Y.Kondr., Elix & A.Thell, whereas those of the latter appear to be with the Antarctic endemic, *C. schofieldii* C.W. Dodge.

**Key Words:** biodiversity, lichens, littoral zone, mallee, South Australia.

### Introduction

The lichen genus *Caloplaca* is one of the largest in the world. The number of species involved is difficult to estimate given the geographic gaps in knowledge, although recently Arup et al. (2013) suggested in excess of 1000 species for the family Teloschistaceae, of which *Caloplaca* is by far the largest genus. *Caloplaca* is truly cosmopolitan and is well represented at all latitudes (including subpolar regions) as well as at a wide range of altitudes, from the littoral zone to the summits of high mountains. Although found in most vegetation types, including forests, heathlands, savannah woodlands and deserts, it tends to favour more open habitats where it colonises all types of rock, soil, wood, bark and man-made substrates. The genus often occupies a very conspicuous and dominant place in the landscape, being responsible, for example, for the continuous yellowish and orange bands on coastal rocks throughout the world. However, many other species are less conspicuous, and may lack these pigments or have them limited only to their tiny fruiting bodies. In general, the genus is characterised by an essentially crustose thallus, biatorine to lecanorine apothecia, asci of the *Teloschistes*-type (Honegger 1978) and hyaline, polardiblastic ascospores; that is, two-celled spores where the locules are separated by a thick septum pierced by a central channel.

In recent years, the phylogeny and systematics of the whole Teloschistaceae has been under investigation using DNA sequence data (e.g. see Gaya et al. 2012). It has become evident that the genus as currently understood is artificial and simply a convenient ‘place holder’ for many crustose species that may be only distantly related (Søchting & Lutzoni 2002). A new overview of the family was published recently (Arup et al. 2013), employing 39 genera and extensively subdividing *Caloplaca* itself. However, as noted by those

authors, few of the genera can be recognised, at least at this stage, by traditional morphological and chemical characters, nor have all the species been included in the molecular analyses. Thus at least for the foreseeable future, it is inevitable and expedient that new taxa will continue to be described (and so brought to the attention of phylogenetic researchers) in *Caloplaca*, rather than in its newly instated segregate genera.

Australia is undoubtedly a hot-spot of speciation for the genus. Kondratyuk et al. (2012) list 122 species, based on an extensive investigation spanning many years that led to the description of many new taxa (Kärnefelt & Kondratyuk 2004; Kondratyuk et al. 2007a, 2007b, 2009a, 2009b, 2010, 2011; Lumbsch et al. 2011). The revision of the genus in Australia, however, is in no way complete, and many areas remain under-investigated and the description of further new species is underway.

Kangaroo Island, with its Mediterranean climate, extensive coastline, complex geology that includes calcareous and siliceous rock types, and wide range of heathlands and woodlands, is an ideal habitat for *Caloplaca*. Thus it was no surprise that despite the large number of species already documented for the southern Australian region, the detailed lichenological surveys of the first author yielded species new to science. For reasons indicated above, we describe these species in the genus *Caloplaca* pending molecular investigation of their phylogenetic relationships.

### Methods

The study is based on collections of the authors, housed in the Tasmanian Herbarium (HO) and the lichen herbarium of M.H. Kholodny Institute of Botany of National Academy of Sciences of Ukraine (KW-L). Descriptions are based on hand-cut sections of the ascomata examined at high-power with a light

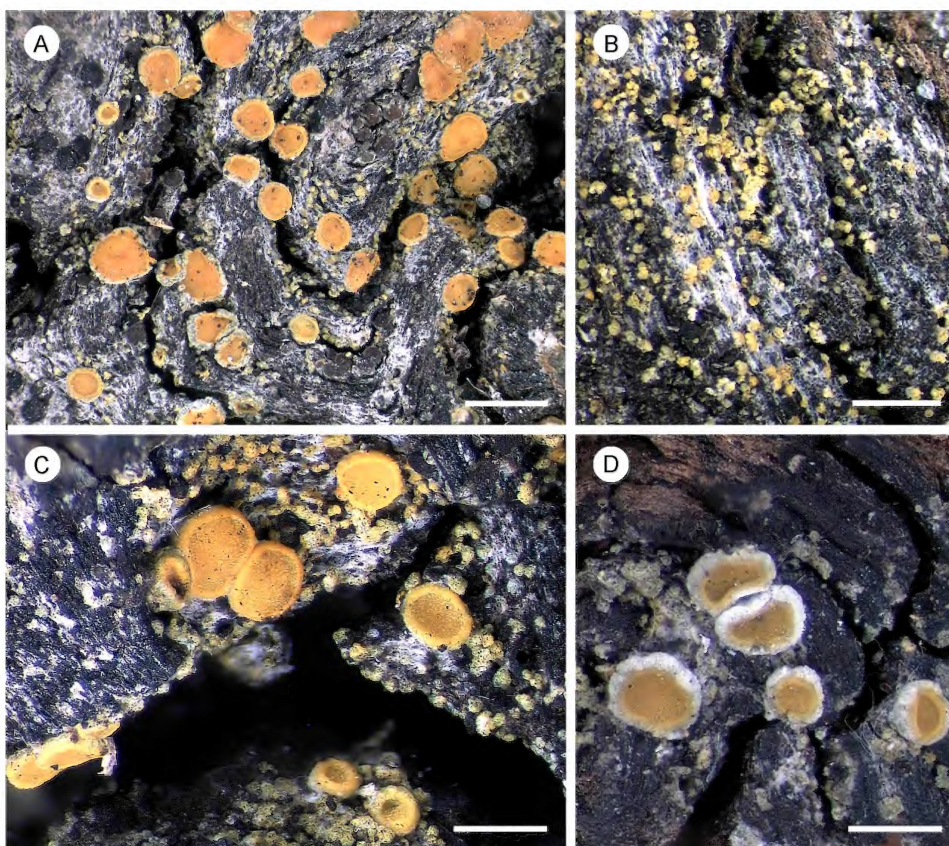


Fig. 1. *Caloplaca gilfillaniorum* (holotype): **A** general habit; **B** detail of sterile thallus comprising isidioide granules; **C** detail of young biatorine apothecia; **D** detail of zeorine apothecia with both the proper and the thalline exciples showing. Scale bar: **A** 1 mm, **B–C** 500  $\mu$ m.

microscope. Mounting media included water, 15% KOH and lactophenol cotton blue after pretreatment with KOH. Measurements given in the description of apothecial tissues, asci and ascospores are based on mounts in water only. Measurements of ascospores and ascospore septa are based on 100 observations for each species and are presented in the form 5<sup>th</sup> percentile–average–95<sup>th</sup> percentile; outlying values are given in brackets. The chemistry of the new species was determined by Prof. J.A. Elix, Canberra, using high performance liquid chromatography (Elix et al. 2003).

### Taxonomy

#### 1. *Caloplaca gilfillaniorum* Kantvilas & S.Y.Kondr., *sp. nov.*

*Caloplacae kaernefeltii similis sed thallo isidioideo, sorediis destituto, apotheciis parvioribus, 0.3–0.8 mm latis, biatorinis vel zeorinis, ascosporis maioribus, 12–17  $\mu$ m longis, 6–8.5  $\mu$ m latis et O-methylvioxanthinum destituto differt.*

**Mycobank no.:** MB804701

**Typus:** SOUTH AUSTRALIA, **Kangaroo Island:** Creek Bay Farm ('Carew'), 35°51'S 138°06'E, 100 m alt., on old dead mallee root in rough pasture, 25 Sep. 2011, *G. Kantvilas 417/11* (holo.: HO 563154; iso.: AD, KW-L).

*Thallus* granular-areolate, forming irregular, undelimited patches to c. 10 cm wide, frequently interrupted by other lichens; individual areoles and granules minute, to 0.05–0.1 mm wide, greyish green to greenish yellow, becoming brighter yellow in more elevated parts, wart-like or becoming elongate, ascending and isidium-like, widely scattered and separate, rarely clustered together. *Apothecia* 0.3–0.8 mm wide, scattered, bright pure yellow, sometimes a little orange-yellow when older, mostly biatorine when very young, soon developing a thalline exciple, initially on the underside, at maturity mostly zeorine, with a  $\pm$  complete, minutely crenulate, greyish green thalline exciple, in section with outer parts interspersed with golden-yellow crystals that turn crimson and dissolve in KOH; disc concave at first, soon becoming plane or a little undulate when old; thalline exciple in section

Table 1. Salient characters of *Caloplaca gilfillaniorum* and some other corticolous or lignicolous species

taxon (source of data)	thallus	apothecia	apothecial disc	ascospores	hymenium	major chemical constituents	distrib.
<i>C. gilfillaniorum</i> (this paper)	of minute greyish green to greenish yellow, isidioid granules	biatorine to zeorine, 0.3–0.8 mm diam.	yellow	8/ascus, polardiblastic, 12–17 × 6–8.5 µm; septum 3–7 µm	without oil droplets	parietin	SA
<i>C. kaernefeltii</i> (Kondratyuk et al. 2009b)	absent, or of orange to orange-green granules that become isidioid or sorediate	lecanorine, 0.4–2 mm diam.	rose-red	8/ascus, polardiblastic, 12–13 × 6–8 µm; septum 4–7 µm	without oil droplets	parietin, O-methyl vioxanthin	WA, SA, Vic, Tas
<i>C. tibellii</i> (Kondratyuk et al. 2009b)	absent, or of scattered, whitish granules with abundant, yellow soredia	biatorine, 0.3–0.5 mm diam.	yellow	usually single in the ascus, polardiblastic, 13–16 × 5–7 µm; septum 5–7 µm	without oil droplets	parietin	WA
<i>C. bassiae</i> (this paper)	continuous, crustose, pale brownish to grey, with yellow, cylindrical isidia 50–60 µm wide	biatorine, 0.3–1 mm diam.	yellow to orange	8/ascus, polardiblastic, 13–25 × 7–9 µm; septum 6–11 µm	with numerous oil droplets	fragilin	Qld, NSW, extra-Austral.
<i>C. aseptatospora</i> (Kondratyuk et al. 2009b)	continuous, crustose, grey to whitish grey, with concolorous granular to ± spherical isidia 40–60 µm wide	zeorine to lecanorine, 0.4–0.9 mm diam.	brownish orange	1–2/ascus, mainly simple, 11–14 × 6–8 µm; septum 5–6 µm	without oil droplets	fragilin	Qld
<i>C. pulcherrima</i> (Kondratyuk et al. 2007b)	continuous, crustose, dark grey to brownish grey, with isidia-like schizidia 0.1–0.2 mm wide	biatorine, 0.6–1.5 mm diam.	blood red	8/ascus, polardiblastic, 10–12 × 6–7 µm; septum 3–5 µm	without oil droplets	lichexanthone	NSW, Tas, NZ
<i>C. sipmanii</i> (Kondratyuk et al. 2009a)	continuous, crustose, whitish, with cylindrical to coralloid isidia	biatorine, 0.8–1.2 mm diam.	yellowish	8/ascus, polardiblastic, 13–25 × 7–9 µm; septum 6–11 µm	without oil droplets	lichexanthone, rhein	Qld
<i>C. elixii</i> (Kärnefelt & Kondratyuk 2004)	continuous, crustose to squamulose, greenish yellow-orange, with marginal phyllidia and isidioid granules	lecanorine, 0.3–2 mm diam., yellow or whitish pruinose	brown-orange with a yellow or whitish pruina	8/ascus, 1–3 (–4)-septate, 16–21 × 5.5–7 µm; septum very thin	without oil droplets	not known	WA, SA, Vic, Qld, NSW, Tas
<i>C. yammeraensis</i> (Kondratyuk et al. 2009b)	continuous, crustose, greenish grey or dark grey, with whitish grey isidia-like schizidia and soredia	lecanorine, 0.4–1 mm diam.	dark brown, ± with a white pruina	8/ascus, polardiblastic, 15–19 × 7–8 µm; septum 5–9 µm	without oil droplets	nil	WA

60–90 (–100) µm thick, with a cortical layer 10–30 µm thick composed of hyphae to 3–5 µm wide; proper exciple 20–70 µm thick in the uppermost lateral part, composed of radiating, interwoven hyphae 2–5 µm wide, in the basal part (beneath the subhymenium) 20–40 µm thick, composed of rather parenchymatous hyphae 4–7 µm wide. *Subhymenium* 50–70 µm thick, hyaline, not interspersed with oil droplets. *Hymenium* 50–70 µm thick, not interspersed; *paraphyses* of the *bermaguiana*-type, 1.5–2 µm thick, with occasional oil cells 3–6 µm wide and apices usually expanded to 2.5–5 µm; *asci*

8-spored, 45–55 × 12–17 µm. *Ascospores* polardiblastic, ellipsoid to broadly fusiform, sometimes with somewhat attenuated apices, (11–) 12–14.2–17 (–18) × (5–) 6–7.1–8.5 (–10) µm; septum 3–5–7 (–11) µm thick. *Pycnidia* not found. **Fig. 1.**

*Chemistry.* Thallus and apothecia K+ brownish purple to crimson-purple; containing parietin, detected by h.p.l.c.

*Etymology.* This species is named in honour of Andy and Kate Gilfillan, friends of the first author and owners

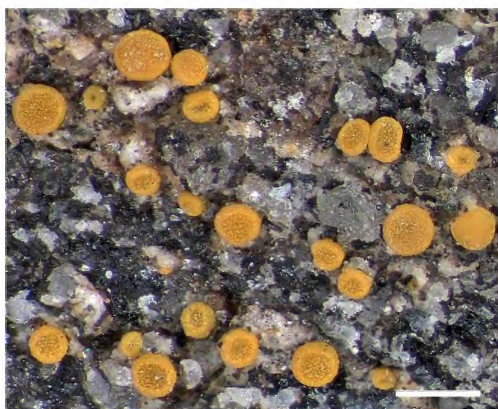


Fig. 2. *Caloplaca piscatorica* (holotype): habit. Scale bar 500  $\mu$ m.

of the property where the type specimen and many other fascinating lichens have been collected.

**Ecology and distribution.** At present, *Caloplaca gilfillaniorum* is known only from the type collection from the Dudley Peninsula, Kangaroo Island. It grew on the dead wood of old mallee lignotubers, scattered in a roughly cleared sheep pasture. Given its habitat, it is anticipated that this species is more widely distributed. Associated lichen species included *Amandinea lignicola* var. *australis* Elix & Kantvilas, *A. punctata* (Hoffm.) Coppins & Scheid., *Lecanora saligna* (Schrad.) Zahlbr., *Lecidella xylogena* (Müll. Arg.) Kantvilas & Elix and a species of *Glonium*.

**Remarks.** *Caloplaca gilfillaniorum* appears to be most closely related to *C. kaernefeltii* S.Y.Kondr., Elix & A.Thell, which also has a poorly developed thallus of orange-green granules that may often be isidium-like. However, that species differs in that the thallus granules eventually become  $\pm$  sorediate, it has very distinctive, large (0.4–2 mm diam.), lecanorine apothecia with a red to rose-red or brownish red disc and white thalline exciple, and the ascospores, although falling within the range of those of *C. gilfillaniorum*, are somewhat shorter and narrower (12–13  $\times$  4–7  $\mu$ m); it also differs chemically by containing high concentrations of *O*-methylvoixanthin in addition to parietin. Significantly, *C. kaernefeltii* also occurs on Kangaroo Island, albeit in a starkly different habitat to *C. gilfillaniorum*, namely in swampy, *Melaleuca*-dominated coastal woodland. On the basis of thallus morphology alone, *C. gilfillaniorum* is also similar to *C. tibellii* S.Y.Kondr. & Kärnefelt, which also has a rather poorly developed, indistinct thallus and occurs on wood, but differs in becoming richly sorediate and having biatorine apothecia where the proper exciple is very thin and soon  $\pm$  excluded, making the apothecia appear immarginate.

In addition to these species, there are several other corticolous isidioid *Caloplaca* species in the

Australian flora with which the new species can be compared. These include: *C. bassiae* (Willd. ex Ach.) Zahlbr., *C. aseptatospora* S.Y.Kondr. & Kärnefelt, *C. pulcherrima* (Müll. Arg.) S.Y.Kondr. & Kärnefelt, *C. sipmannii* S.Y.Kondr., Kärnefelt, Elix & J.Vondrák, *C. elixii* S.Y.Kondr. & Kärnefelt and *C. yammeraensis* S.Y.Kondr., Kärnefelt & Elix. However, all these species present a combination of thallus, apothecial, ascospore and chemical characters starkly different from that of *C. gilfillaniorum* (see Table 1 for summary).

Due to its hard substrate (lignotubers), we also compared *C. gilfillaniorum* to some isidiate saxicolous species, notably *C. archeri* Kalb, S.Y.Kondr., Elix & Kärnefelt, *C. clavatoisidiata* S.Y.Kondr., Kärnefelt & J.Vondrák, *C. ferdinandmuelleri* S.Y.Kondr. & Kärnefelt and *C. kiamae* S.Y.Kondr. & Kärnefelt. Again, the combination of key characters clearly distinguishes these species from *C. gilfillaniorum* and, with the exception of *C. kiamae*, none of the species mentioned occurs in South Australia.

Molecular data is very limited for Australian *Caloplaca* species, although investigations by the second author (SYK) are ongoing and results will be reported elsewhere. However, molecular phylogeny data based on nuclear (ITS1/ITS2 and LSU portions) and mitochondrial (12S SSU) DNA sequences of *Caloplaca gilfillaniorum* and *C. kaernefeltii* confirm that these species are distinct and suggest that together they belong to a robust, monophyletic branch that also includes some South African species (S.Y. Kondratyuk, unpubl. data).

**Also examined** (*Caloplaca bassiae*)

[INDIA:] Malabar (H-ACH 1752, holotype). AUSTRALIA, QUEENSLAND: Green Island, 27.4 km NE of Cairns, 16°46'S 145°58'E, 0 m alt., 26.viii.1976, J.A. Elix 2597 (CANB); Eimeo Beach, near Mackay, 21°12'S 149°06'E, 60 m alt., 11.viii.1974 J.M. Gilbert 74/705 (HO); Newell Beach, 6 km NE of Mossman, 16°26'S 145°24'E, 3 m alt., 5.xii.1990, H. Streimann 45970 (CANB); Crediton State Forest, 16 km SW of Finch Hatton, 21°15'S, 148°31'E, 700 m alt., 1.vii.1986, J.A. Elix 21083 & H. Streimann (CANB).

## 2. *Caloplaca piscatorica* Kantvilas & S.Y.Kondr., *sp. nov.*

*Caloplacae schofieldii similis sed apotheciis citrinis, persistente biatorinis et ascosporis brevioribus, 7.5–11  $\mu$ m longis, 4–5  $\mu$ m latis differt.*

**Mycobank no.:** MB804702

**Typus:** SOUTH AUSTRALIA, **Kangaroo Island:** northern end of Antechamber Bay, 35°47'S 138°04'E, 0 m alt., on seashore rocks in underhangs and crevices, 18 September 2012, G. Kantvilas 510/12 (holo.: HO; iso.: AD, KW-L).

**Thallus** inapparent, evident at most by undelimited, paler areas of substrate or as pale greyish or brownish spots in the vicinity of the apothecia. **Apothecia** 0.25–0.6 mm wide, scattered or aggregated, bright citrine yellow, persistently biatorine, interspersed at the outer edges with yellow crystals that turn crimson and dissolve in KOH; disc persistently plane; proper exciple persistent, in section to 35–65  $\mu$ m thick in the uppermost lateral part

**Table 2.** Salient characters of *Caloplaca piscatorica* and some superficially similar species

taxon (source of data)	thallus	apothecia	apothecial disc	ascospores	major chemical constituents	ecology and distribution
<i>C. piscatorica</i> (this paper)	± absent	biatorine, 0.25–0.6 mm diam.	yellow	8/ascus, polardiblastic, 7.5–11 × 4–5 µm; septum 0.5–2.5 µm	parietin	sea-shore rocks; SA
<i>C. schofieldii</i> (Dodge 1973; Øvstedal & Lewis Smith 2001; this paper)	insignificant, areolate or granular on a black hypothallus	lecanorine, 0.2–0.4 mm diam.	orange-yellow to orange	8/ascus, polardiblastic, 9–13 × 4–6 µm; septum 1–2 µm	not known	rocks; Antarctica
<i>C. johnstonii</i> (Dodge 1948; Øvstedal & Lewis Smith 2001)	rimose-areolate and olive, or absent, with a beige hypothallus	lecanorine, 0.2–0.5 mm diam.	orange-yellow	8/ascus, polardiblastic, 10–13 × 5.5–7 µm; septum 2–3 µm	not known	sea-shore rocks; Antarctica and nearby islands
<i>C. cliffwetmorei</i> (Kondratyuk et al. 2009b)	very thin or endophloedal, whitish to whitish- grey, darkish grey near the apothecia	zeorine to lecanorine, 0.2–0.6 mm diam.	dull orange to brownish with yellow pruina	8/ascus, polardiblastic, 10–12 × 5–6 µm; septum 4–5 µm	parietin	bark; WA, Vic, Tas
<i>C. aegatica</i> (Giralt et al. 1992; Kondratyuk et al. 2004)	thin, crustose, continuous to rimose, grey to greyish-brown or greyish-yellow	zeorine, 1–1.8 mm diam., with a golden- yellow proper exciple and a greyish thalline exciple	orange to dark orange	8/ascus, polardiblastic, 10–15 × 7–9 µm; septum 5–8 µm	not known	bark; Mediterranean region and Atlantic islands

and composed of radiating, interwoven hyphae 3–5 µm thick with occasional oil cells to 7 µm wide, in the basal part becoming very thin and ± disappearing; scattered algal cells present below subhymenium. *Subhymenium* to 40–70 (–100) µm thick, interspersed with scattered oil droplets to 3–4 µm diam. *Hymenium* 45–65 µm thick, not interspersed with oil droplets; *asci* 8-spored, 35–48 × 11–15 µm; *paraphyses* 1.5–2 µm thick, sometimes with the uppermost cells with oil vacuoles to 2–3 (–4) µm diam. *Ascospores* polardiblastic, narrowly ellipsoid to somewhat widened at the septum, (6–) 7.5–9.2–11 (–12) × (3.5–) 4–4.5–5 (–6) µm; septum 0.5–1.5–2.5 (–3) µm thick. *Pycnidia* not found. **Fig. 2.**

**Chemistry.** Apothecia K+ crimson-purple; containing parietin, detected by h.p.l.c.

**Etymology.** The species epithet (derived from the Latin for ‘fishing’) alludes to the attributes of the type locality and the activities of the collector when this species was discovered.

**Ecology and distribution.** At present, *Caloplaca piscatorica* is known only from the type locality on the Dudley Peninsula, Kangaroo Island, where it grew on steeply sloping laterite rock plates along the sea shore. The upper parts of these rocks are abundantly colonised by a typical littoral community of crustose lichens that includes *Buellia aeruginosa* A.Nordin et al., *B. halonia* (Ach.) Tuck., *Caloplaca eos* S.Y.Kondr.

& Kärnefelt, *Catillaria austrolittoralis* Kantvilas & van den Boom, *Tylothallia pahiensis* (Zahlbr.) Hertel & Kilius and *Jackelixia ligulata* (Körb.) S.Y.Kondr. et al. Whereas small thalli of *C. piscatorica* may occur in this association, the best colonies of this species tend to be restricted to sheltered crevices and underhangs, well within the zone of direct influence of sea-water, where *Verrucaria subdiscreta* P.M.McCarthy and only depauperate thalli of the species mentioned above grow.

**Remarks.** *Caloplaca piscatorica* is a distinctive species, recognised in the field by its lack of a visible thallus and its scattered, persistently biatorine, lemon-yellow apothecia. The apothecia resemble those of a species of *Candelariella* Müll.Arg., a genus that is readily distinguished from *Caloplaca* by the absence of K+ crimson, anthraquinone pigments, its *Lecanora*-type asci and simple ascospores.

On the basis of literature pertinent to the Southern Hemisphere (*viz.* Øvstedal & Lewis Smith 2001; Wirth & Kondratyuk 2010; Kondratyuk et al. 2012) and available herbarium material, the new species appears to be closest to two Antarctic endemic taxa, *C. schofieldii* C.W.Dodge and *C. johnstonii* (C.W.Dodge) Sochting & Olech. Both of these species differ from *C. piscatorica* chiefly by having lecanorine apothecia, an orange-yellow apothecial disc and somewhat larger ascospores, as well as in several more subtle features (see Øvstedal & Lewis Smith 2001 and Table 2). Dodge (1973) also describes a

black hypothallus in *C. schofieldii*, although no mention of this characteristic feature is made by Castello & Nimis (1995) who studied his type specimens. We also compared *C. piscatorica* to the corticolous Australian species, *C. cliffwetmorei* S.Y.Kondr. & Kärnefelt, and its Northern Hemisphere relative, *C. aegatica* Giralt, Nimis & Poelt. Both have zeorine to lecanorine apothecia, and display further thallus, apothecial and ascospore features that readily distinguish them from the new species (Table 2).

#### Additional specimen examined

SOUTH AUSTRALIA. **Kangaroo Island:** type locality, 18.x.2011, G. Kantvilas 489/11 (HO, LD, KW-L).

#### Also examined (*Caloplaca schofieldii*)

ANTARCTICA: Southern Victoria Land, Lower Taylor Valley, 77°40'S 163°14'E, 2.xii.1989, R.D. Seppelt 17773, 17774 (HO); Vestfold Hills, NE end of Lake Druzhby, 68°34'30"S 78°23'45"E, 15 m alt., 16.i.1979, R.D. Seppelt 8291 (HO); Ross Island, Cape Bird area, 77°14'13.5"S 166°25'12.5"E, 135 mm alt., 26.i.2000, R.D. Seppelt 21988 (HO).

### Acknowledgements

We thank Jean Jarman for producing the illustrations for this paper, and Jack Elix for determining the chemistry of the new species.

### References

- Arup, U., Söchting, U. & Frödén, P. (2013). A new taxonomy of the family Teloschistaceae. *Nordic Journal of Botany* 31: 16–83.
- Castello, M. & Nimis, P.L. (1995). A critical revision of Antarctic lichens described by C.W. Dodge. *Bibliotheca Lichenologica* 57: 71–92.
- Dodge, C.W. (1948). Lichens and Lichen Parasites. *British-Australian-New Zealand Antarctic Research Expedition 1929–1931*. Reports, Series B, Zoology-Botany 7: 1–276.
- Dodge, C.W. (1973). *Lichen Flora of the Antarctic Continent and Adjacent Islands*. (Phoenix Publishing: Canaan, New Hampshire).
- Elix, J.A., Giralt, M. & Wardlaw, J.H. (2003). New chlorodepsidones from the lichen *Dimelaena radiata*. *Bibliotheca Lichenologica* 86: 1–7.
- Gaya, E., Högnabba, F., Holguin, Á., Molnar, K., Fernández-Brime, S., Stenroos, S., Arup, U., Söchting, U., Van den Boom, P., Lücking, R., Sipman, H.J.M. & Lutzoni, F. (2012). Implementing a cumulative supermatrix approach for a comprehensive phylogenetic study of the Teloschistales (Pezizomycotina, Ascomycota). *Molecular Phylogenetics and Evolution* 63: 374–387.
- Giralt, M., Nimis, P.L. & Poelt, J. (1992). Studien über den Formenkreis von *Caloplaca flavorubescens* in Europa. *Cryptogamie, Bryologische und Lichenologische* 13: 261–273.
- Honegger, R. (1978). The ascus apex in lichenized fungi I. The *Lecanora*-, *Peltigera*- and *Teloschistes*-types. *Lichenologist* 10: 47–67.
- Kärnefelt, I. & Kondratyuk, S.Y. (2004). New species of *Caloplaca* (Teloschistaceae) from Australia. *Bibliotheca Lichenologica* 88: 255–265.
- Kondratyuk S.Y., Khodosovtsev A.Y. & Oxner A.N. (2004). *Caloplaca*. In: *Handbook of the Lichens of Russia*. 9. *Fuscideaceae, Teloschistaceae*: 38–235. (Nauka: Sankt-Peterburg).
- Kondratyuk, S.Y., Kärnefelt, I., Elix, J.A. & Thell, A. (2007a). New species of the genus *Caloplaca* in Australia. *Bibliotheca Lichenologica* 95: 341–386.
- Kondratyuk, S.Y., Kärnefelt, I., Elix, J.A. & Thell, A. (2007b). Contributions to the Teloschistaceae of Australia. *Bibliotheca Lichenologica* 96: 157–174.
- Kondratyuk, S.Y., Kärnefelt, I., Elix, J.A. & Thell, A. (2009a). New *Caloplaca* species from Australia. *Bibliotheca Lichenologica* 99: 259–278.
- Kondratyuk, S.Y., Kärnefelt, I., Elix, J.A. & Thell, A. (2009b). Contributions to the Teloschistaceae, with particular reference to the Southern Hemisphere. *Bibliotheca Lichenologica* 100: 207–282.
- Kondratyuk, S.Y., I. Kärnefelt, Thell, A. & Elix, J.A. (2010). Six new species of *Caloplaca* (Teloschistaceae, Ascomycota) from Australasia. *Australasian Lichenology* 66: 30–43.
- Kondratyuk, S.Y., Elix, J.A., Kärnefelt, I. & Thell, A. (2011). Four New *Caloplaca* species with depsidones from Australia. *Bibliotheca Lichenologica* 106: 179–186.
- Kondratyuk, S.Y., Elix, J.A., Kärnefelt, I. & Thell, A. (2012). An artificial key to Australian *Caloplaca* species (Teloschistaceae, Ascomycota). *Bibliotheca Lichenologica* 108: 141–160.
- Lumbsch, H.T., Ahti, T., Altermann, S. et al. (100 others) (2011). One hundred new species of lichenized fungi: a signature of undiscovered global diversity. *Phytotaxa* 18: 1–137.
- Øvstedal, D.O. & Lewis Smith, R.I. (2001). *Lichens of Antarctica and South Georgia: A Guide to Their Identification and Ecology*. (Cambridge University Press, Cambridge, England).
- Söchting, U. & Lutzoni, F. (2003). Molecular phylogenetic study at the generic boundary between the lichen-forming fungi *Caloplaca* and *Xanthoria* (Ascomycota, Teloschistaceae). *Mycological Research* 107: 1266–1276.
- Wirth, V. & Kondratyuk, S.Y. (2010). Neue Arten der Flechtenfamilie Teloschistaceae aus der Namibwüste und der Sukkulenten-Karoo (SW-Afrika). *Herzogia* 23: 179–194.